K$_L^o \to \pi^0 \nu \bar{\nu}$

Kopio

RSVP

Arizona State U., BNL, U. of Cincinnati, IHEP-Protvino, INR-Moscow, KEK, Kyoto U. of Education, Kyoto U., U. of Montreal, U. of New Mexico, INFN-U. of Perugia, Stony Brook U., TRIUMF, U. of British Columbia, U. of Virginia, VPI&SU, Yale U. , U. of Zurich
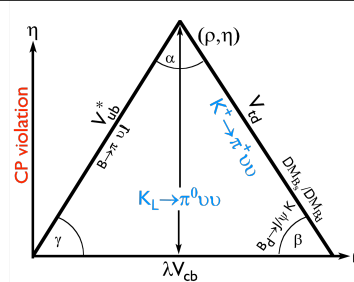
KOPIO proposes to measure a minimum of 40 events at the Standard Model level, with a signal to background of 2:1.

MOTIVATION

The "Golden" mode of decay for the K$_L^o$ is unique among potential SM observables. It is entirely driven by CP violation due to the CP properties of the K$_L^o$, π^o and the relevant neutral transition current. In the SM, it is GIM-suppressed to the one-loop level and top-quark dominated. Hadronic uncertainties are eliminated by comparison with Ke3. Thus the branching ratio (BR) of the decay is calculable to 2% in terms of the Wolfenstein parameters and m$_t$:

$$BR = 2.1 \cdot 10^{-10} \, \eta^2 \, A^4 \, X^2 (m_t^2/M_W^2)$$
$$\cong (3.0 \pm 0.6) 10^{-11}$$

A clean measure of the height of the unitarity triangle is provided by the BR. All other parameters being known implies that the relative error in η is half that on the BR.
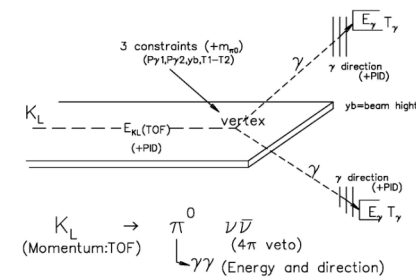
$K_L^0 \to \pi^0 \nu \bar{\nu}$	$\mathrm{Im}(V_{ts}^* V_{td})$	**KOPIO**	"Jarlskog invariant" $|J_{CP}|$
$K^+ \to \pi^+ \nu \bar{\nu}$	$|V_{ts}^* V_{td}|$	**E949**	$2A = \left| \mathrm{Im} V_{ts}^* V_{td} \right| \lambda \left(1 - \frac{\lambda^2}{2}\right)$
$B_d \to \psi K_S$	$\sin(2\beta)$	BABAR, BELLE,CDF,D0	
$\dfrac{x_s}{x_d}$	$\left| \dfrac{V_{ts}}{V_{td}} \right|$	CDF, D0, LHCB, BTEV	
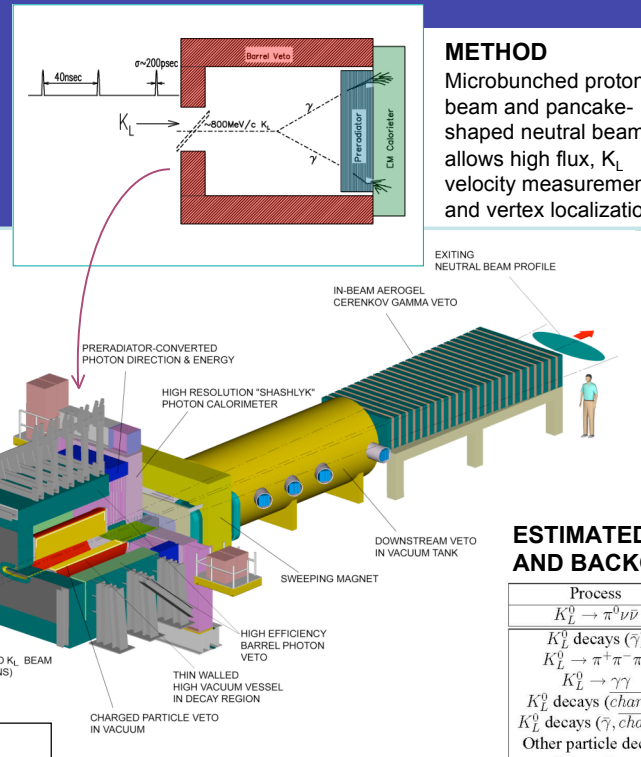
METHOD

Microbunched proton beam and pancake-shaped neutral beam allows high flux, K$_L$ velocity measurement and vertex localization.

MEASURING:

- Time of flight of the KL to allow kinematic selection to reject backgrounds.
- The converted γ direction.
- The γ energies with high precision.
- All other detectable particles that are emitted in the decay in order to veto the events

$K_L \to \pi^0 \, \nu \bar{\nu}$ (Momentum:TOF) (4π veto), $\gamma\gamma$ (Energy and direction)

EXITING NEUTRAL BEAM PROFILE

IN-BEAM AEROGEL CERENKOV GAMMA VETO

PRERADIATOR-CONVERTED PHOTON DIRECTION & ENERGY

HIGH RESOLUTION "SHASHLYK" PHOTON CALORIMETER

DOWNSTREAM VETO IN VACUUM TANK

SWEEPING MAGNET

HIGH EFFICIENCY BARREL PHOTON VETO

MICROBUNCHED K$_L$ BEAM (WITH NEUTRONS)

THIN WALLED HIGH VACUUM VESSEL IN DECAY REGION

CHARGED PARTICLE VETO IN VACUUM

ESTIMATED EVENT LEVELS FOR SIGNAL AND BACKGROUNDS:

Process	Modes	Main source	Events
$K_L^0 \to \pi^0 \nu \bar{\nu}$			41
K_L^0 decays ($\bar{\gamma}$)	$\pi^0 \pi^0, \pi^0 \pi^0 \pi^0, \pi^0 \gamma\gamma$	$\pi^0 \pi^0$	12.8
$K_L^0 \to \pi^+ \pi^- \pi^0$			0.65
$K_L^0 \to \gamma\gamma$			0.02
K_L^0 decays ($charge$)	$\pi^\pm e^\mp \nu, \pi^\pm \mu^\mp \nu, \pi^+ \pi^-$	$\pi^- e^+ \nu$	0.02
K_L^0 decays ($\bar{\gamma}, charge$)	$\pi^\pm l^\mp \nu \gamma, \pi^\pm l^\mp \nu \pi^0, \pi^+ \pi^- \gamma$	$\pi^- e^+ \nu \gamma$	4.4
Other particle decays	$\Lambda \to \pi^0 n, K^- \to \pi^- \pi^0, \Sigma^+ \to \pi^0 p$	$\Lambda \to \pi^0 n$	0.01
Interactions	n, K_L^0, γ	$n \to \pi^0$	0.2
Accidentals	n, K_L^0, γ	n, K_L^0, γ	0.8
Total Background			**18.9**

May 2004 BEAM EXTINCTION TEST

Using a 4.5 MHz cavity for beam extraction from the AGS, a microbunch width of 3ns and an interbunch extinction (number of events between microbunches relative to the microbunch) of ~10^{-5} was observed. The $\bar{e}$ p's and π's in the beam were electrostatically separated and the residual π's suppressed by TOF cuts. Two small scintillators were used to trigger and measure the timing of the microbunched beam, and a 3x3 prototype shashlyk calorimeter was used for the energy measurement. The extinction result is better than what was predicted by simulations.

Preliminary

interbunch region 1: 4 events; interbunch region 2: 2 events

RF microbunching (ns)
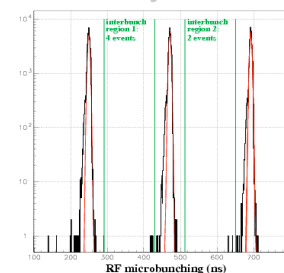
CURRENT STATUS AND SCHEDULE

- Technologies have matured in an R&D phase for 3 years.
- Receiving $2.5M this year for advanced planning.
- Integration and configuration control initialized.
- Re-baselining of the detector is in process with the review set in early 2005.
- RSVP construction start in FY05 requested in the NSF budget.

for more info: www.pubweb.bnl.gov/people/e926